FLASH FLOOD WARNING SYSTEM FOR SMALL RURAL COMMUNITIES

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ABSTRACT

This paper presents some aspects concerning early wireless flood alarm systems for small rural communities.
Due to recent heavy rain period and great amount of water per square meter over a short period of time, one must pay attention to several devices able to prevent the loss of life's and material damages produced by local rapid and intense floods.
One solution of a flood alarm system can be a device containing a flow rate transducer, power source and wireless module including directional antenna.
The proposed alarm device can be placed on the rivers at considerable distance from the populated area; the flood alarm signal is transmitted in real time by the directional antenna to the intervention center so they can assure the adequate protection for the peoples and major objectives.

1. INTRODUCTION

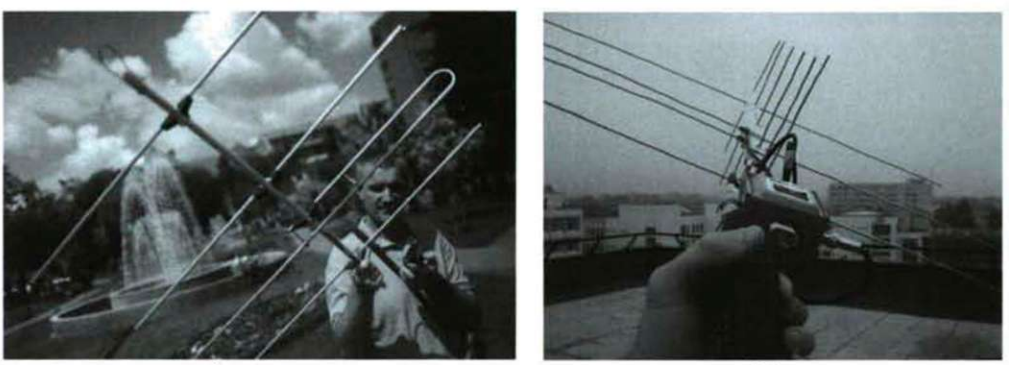
Floods are natural threading phenomena that can produce loss of human lifes, material damages and economical draw-back effects on a large scale. "A sudden local flood of great volume and short duration" can bee a definition provided to flashfloods. The causes can be heavy rain or melting snow in conjunction with rain, dam failure can also produce important flash flood.
Rapid flash flood development causes the los of human life's and important material damages.
Among the category of floods the sudden flood or the so called flash flood can develop without warning and develop very rapidly with high velocity and important displacement forces. Those characteristics make from flash floods an important risk factor for the inhabited areas.
Small communities located outside the general warning system guarding the important water streams are exposed to flash floods especially when the community is at the base of a mountain area or a large reservoir.
This paper proposes a possible solution for small communities exposed to the flash flood impact. The base idea is to achieve an early warning of the authorities, both acoustical and by wireless message.

2. STRUCTURE OF THE PROPOSED WARNING SYSTEM

It is important that small endangered communities are provided with early warning systems, the warning can be acoustic or by data transmission (wireless or by cable).
The means to produce early warning can consist of :

- power source
- communication module
- level, flow rate transducers

The power source must supplies about 1.5 A in emission and about 0.15 A in stand-by and 7.2 to 12 V. A Li-ion or Ni-Mh battery pack can fulfill the task and can be reloaded using wind generators or solar cells. Also local electrical network can provide the necessary functioning parameters.
The communication module must achieve point to point contact from the measurement site to the local authorities, the estimated distance to be covered is 10 km, and the maximal emission power is 5 W with a directional antenna like the Yagi-Uda or the log-periodic antenna.
The antenna can be Yagi-Uda or log-periodic type, for the communication tests one four elements VHF Yagi antenna and a 3 elements VHF combined with 6 elements UHF antenna was used, the antenna has a max. 1.5 m boom length and it is about 1 m wide (see Figure. 1).



a) b)

Fig 1. Experimental antenna types

a) 4 elements Yagi with J-pole active element,
b) 3 elements VHF and 6 elements UHF antenna combined on a single boom

The VHF 4 elements antenna pattern is shown in Figure 2.

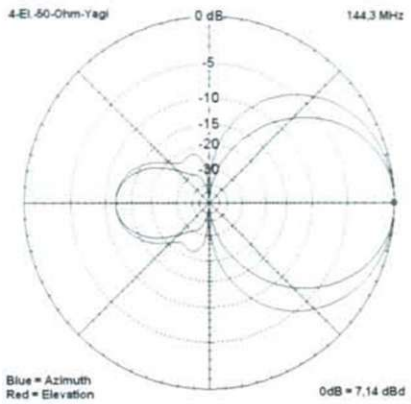


Fig 2. The VHF antenna pattern

The gain of the VHF antenna is about 7 dBd and 10 dBd for the UHF antenna, the power transfer in free space from one antenna to another can be determinate with the relationship:

$$P_R = PFD \cdot A_e = \left(\frac{G_T P_T}{4\pi r^2}\right)\left(\frac{\lambda^2 G_R}{4\pi}\right) = P_T G_T G_R \left(\frac{\lambda}{4\pi r}\right)^2$$

- λ: wavelength [m]
- P_R: power available at the receiving antenna
- P_T: power delivered to the transmitting antenna
- G_R: gain of the transmitting antenna in the direction of the receiving antenna
- G_T: gain of the receiving antenna in the direction of the transmitting antenna

The proposed warning and communication module is a radio communication link consisting of two portable communication devices with max. 5W power and two directional antennas, such the Yagi-Uda or log-periodic.

The level transducer system can be of capacitive type, with two possible solutions shown in Figure 3.

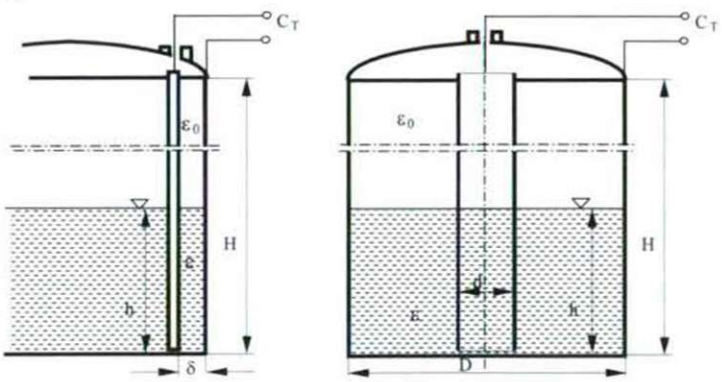


Fig 3. Capacitive level detection system

For the two level detection systems the total capacity C_T depends on the liquid level and in the first case it can be calculated with the relation:

$$C_T = C + C_0 = \frac{b}{\delta}[(\varepsilon - \varepsilon_0)h + \varepsilon_0 H] \qquad C = \varepsilon\frac{b \cdot h}{\delta} \qquad C_0 = \varepsilon_0\frac{b(H-h)}{\delta}$$

For the second type of level detection system the relationships are:

$$C_T = \frac{2\pi}{\ln\left(\frac{D}{d}\right)}[(\varepsilon - \varepsilon_0)h + \varepsilon_0 H] \qquad C = \frac{2\pi\varepsilon h}{\ln\left(\frac{D}{d}\right)} \qquad C_0 = \frac{2\pi\varepsilon_0 (H-h)}{\ln\left(\frac{D}{d}\right)}$$

A possible method for the flow and fluid velocity detection is presented in Figure 4. The flow produces a torque M_i which is measured with two transducers T_1 and T_2.

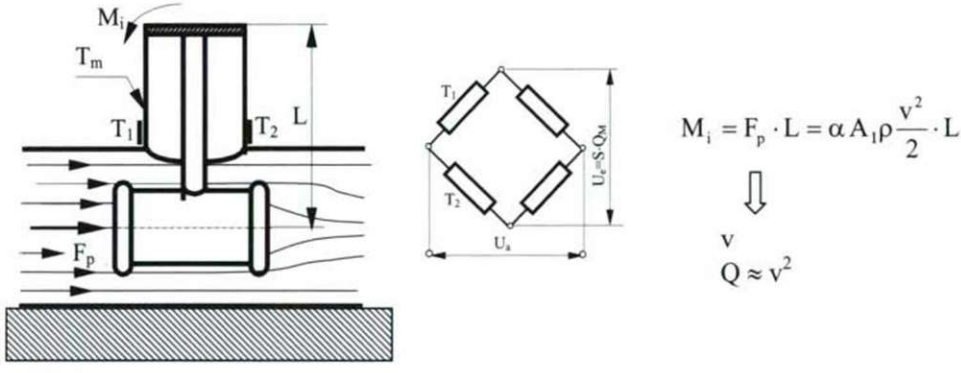


Fig 4. The flow detection system

3. EXPERIMENTAL RESULTS

In order to test the ability of the communication module an experiment was performed using Alinco DJ596E, 5W, portable radio amateur equipment and home-made 4 elements VHF Yagi antenna against the 6 elements UHF antenna. The selected region was a mountain area with dense forest. One point A was 835 m high and the second one B was at 560 m high with 5000 m in between.

The voice FM test was received with S5 on the transceiver for the 4 elements VHF antenna and only S3 for the 6 elements UHF antenna, at point B simulating the authorities point.

4. CONCLUSIONS

The performed test proves that the warning signal from the flow rate transducer provided to the communication module reaches the authorities with good intelligibility.
At a displacement speed of 4m/s for the flash flood, there is a 15 minutes reaction time. This is calculated for 5000 m line of sight distance between the A and B points. For 20 km distance line of sight there is almost one hour reaction time. This aspect becomes important when the flash flood appears during the night when the chance to observe the flood in time is drastically reduced.
The recent flash flood events affecting small villages demonstrate the necessity of such guarding devices in order to save life's and goods.

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